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QUANTUM NUMBERS WORKSHEET - SOLUTIONS

1. State the four quantum numbers, then explain the possible values they may have and what they actually represent.

Principal Quantum Number	n	1 to infinity	Energy level and size of orbital
Azimuthal Quantum Number	l	0 to (n-1)	Shape of orbital
Magnetic Quantum Number	m_l	$-l$ to l	Orientation
Spin Quantum Number	m_s	+1/2, -1/2	Electron spin

2. State the number of possible electrons described by the following quantum numbers

a. n = 3, l = 0 (A single *s* orbital, therefore 2 electrons)

b. n = 3, l = 1 (Three *p* orbitals, therefore 2x3 = 6 electrons)

c. n = 3, l = 2, m_l = -1 (A single *p* orbital, therefore 2 electrons)

d. n = 5, l = 0, m_l = -2, m_s = -1/2 (Such a combination of quantum numbers is not possible)

3. Give the *n* and *l* values for the following orbitals

a. 1s (n = 1, l = 0)

b. 3s (n = 3, l = 0)

c. 2p (n = 2, l = 1)

d. 4d (n = 4, l = 2)

e. 5f (n = 5, l = 3)

4. What is the m_l values for the following types of orbitals?

a. s (l = 0, therefore the only possible value of m_l is 0)

b. p (l = 1, therefore the possible values of m_l are -1, 0, 1)

c. d (l = 2, therefore the possible values of m_l are -2, -1, 0, 1, 2)

d. f (l = 3, therefore the possible values of m_l are -3, -2, -1, 0, 1, 2)

5. How many possible orbitals are there for n =

a. 1 (n = 1, l = 0, m_l = 0, therefore only 1 orbital, the s orbital)

b. 4 (n = 4, l = 0, m_l = 0, one *s* orbital

l = 1, m_l = -1, 0, 1, three *p* orbitals

l = 2, m_l = -2, -1, 0, 1, 2, five *d* orbitals

l = 3, m_l = -3, -2, -1, 0, 1, 2, 3, seven *f* orbitals TOTAL: 1 + 3 + 5 + 7 = 16)

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c. 6 (Follow the same pattern as done in part b., the total is: 1 + 3 + 5 + 7 + 9 + 11 = 36)

*** A note: the maximum number of orbitals at level *n* is n^2.

6. Without referring to a text, periodic table or handout, deduce the maximum number of electrons that can occupy an:

   a. *s* orbital 2x1 = 2 b. the subshell of *p* orbitals 2x3 = 6 c. the subshell of *d* orbitals 2x5 = 10

   d. the subshell of *f* orbitals 2x7=14 e. the subshell of *g* orbitals (*l* = 4) 2x9 = 18

7. How many electrons can inhabit all of the *n*=4 orbitals?

From question 5., there is a maximum of 16 orbitals in total at level n = 4. Since each orbital can take a maximum of 2 electrons, we can have up to 2x16 = 32 electrons at *n* = 4.

OR

A 4s orbital can hold up to 2 electrons, three 4p orbitals can hold up to 2x3=6 electrons, five 4d orbitals can hold up to 2x5=10 electrons, and seven 4f orbitals can hold up to 2x7=14 electrons. The total number of electrons at level n = 4, is 2 + 6 + 10 + 14 = 32.

8. Fill in the blanks with the correct response:

   a. The number of orbitals with the quantum numbers *n* = 3, *l* =2 and m_l = 0 is 1.
   b. The subshell with the quantum numbers *n* = 4, *l* = 2 is d.
   c. The m_l values for a d orbital are -2, -1, 0, 1, 2.
   d. The allowed values of *l* for the shell with *n*=2 are 0, 1.
   e. The allowed values of *l* for the shell with *n*=4 are 0, 1, 2, 3.
   f. The number of orbitals in a shell with *n* =3 is (one s orbital + three p orbital + five d orbitals = 1 + 3 + 5 = 9 total).
   g. The number of orbitals with *n* = 3 and *l* = 1 is 3.
   h. The maximum number of electrons with quantum numbers with *n*=3 and *l*=2 is 2x5 = 10
   i. When *n*=2, *l* can be 0, 1.
   j. When *n*=2, the possible values for m_l are 0 for *l* = 0, and -1, 0, 1 for *l* = 1.
   k. The number of electrons with *n*=4, *l*=1 is 2x3 = 6.
   l. The subshell with *n*=3 and *l*=1 is designated as the 3*p* subshell.
   m. The lowest value of *n* for which a *d* subshell can occur is n= 3.

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9. How many electrons can occupy any single orbital? 2

10. Answer the following questions:

a. What is the value of l for a 4f electron? 3

b. What is the orbital designation for an electron in the 3rd shell and p sublevel? 3p

c. What are the possible values of m_l for a 5d electron? (l = 2 represents a d orbital, therefore the possible values of m_l *are* -2, -1, 0, 1, 2)

d. What is the maximum number of electrons in the 3rd energy level? 2x9 = 18

e. How many orbitals have the following quantum numbers: n =4, l = 2, m_l = -2? 1

f. How many electrons have the following quantum numbers: n =4, l = 2, m_l = -2? 2